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Juggling act of electricity demand and supply in Peninsular Malaysia: Energy efficiency, renewable energy or nuclear?

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ABSTRACT

Energy is the foundation that supports and spurs the socio-economic development of a country. It is a fact that development is not possible without energy and sustainable development is not possible without sustainable energy. As a country that is aiming to become a high-income nation by 2020, Malaysia is in a quandary to come up with a plan for energy security to ensure sustainable economic development, while at a same time striking a balance in the electricity demand-and-supply chain. This paper studies and estimates how these two areas that are often overlooked; energy efficiency and renewable energy can seriously contribute to the local energy sector and find the equilibrium in the electricity demand and supply, and eventually gauge whether a nuclear power plant or more fossil-fuelled power plant is necessary in the near future.

Contents

1. Introduction

Adequate, reliable and affordable electricity supply has been the cornerstone of economic development in Malaysia all this while. It is still an important imperative for Malaysia to follow in order to achieve the desired objectives of Vision 2020 and the more recent aim to become a high-income economy by year 2020. A power crunch in the early 1990s when country's economy was booming has taught local policy makers an important lesson; the need to continuously plan for energy security to ensure sustainable economic development. While Malaysia's electricity supply challenges in the 1990s have since been overcome by the opening up of the industry to allow private sector participation in electricity generation, nation's power industry continues to face major challenges as the country enters its next phase of growth towards a high-income economy.

Recent statements from the government policy and regulatory bodies have laid out some strategies to ensure that nation's energy needs will continue to be assured to power the economic development strategies required to achieve the planned gross domestic

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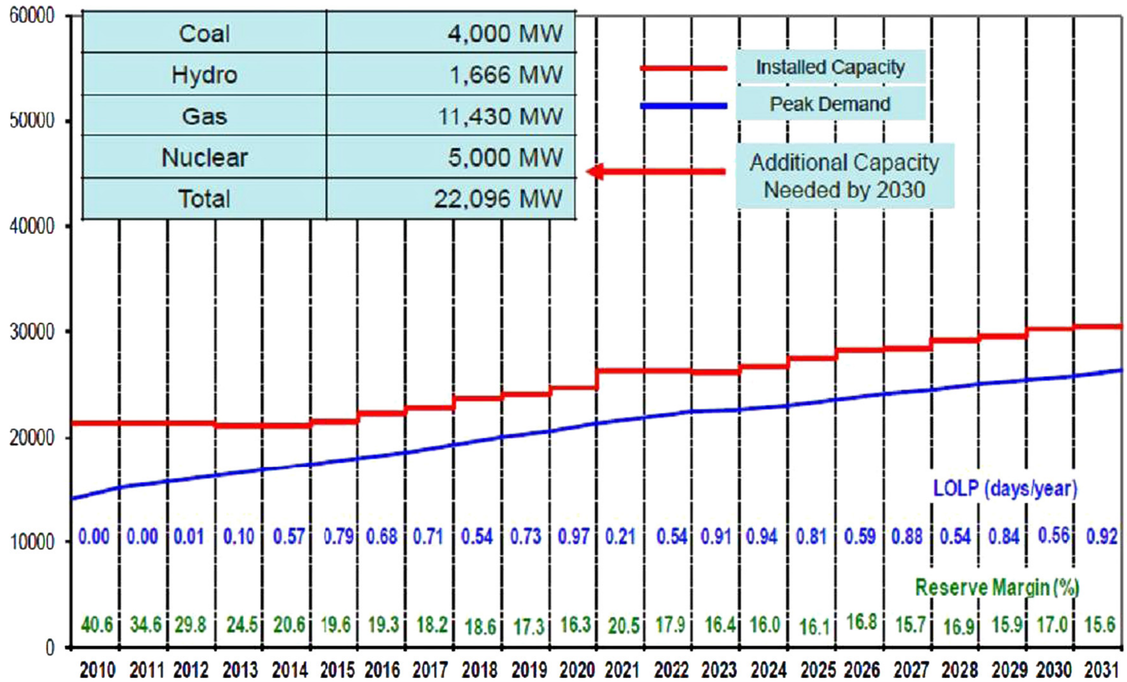

Fig. 1. Peninsular Malaysia power development plan [1].

product (GDP) growth rates desired as mentioned in the Economic Transformation Program (ETP). The then Minister of the Ministry of Energy, Green Technology and Water (KeTTHA), Datuk Seri Peter Chin, when speaking on the "Future Energy in Malaysia" at the Malaysian International Chamber of Commerce and Industry event in April 2012, assured his audience that "Going forward, we will ensure that the energy supply in Malaysia is sufficient, reliable and cost effective to safeguard our regional competitiveness in trade and industry". How does Malaysia plan to ensure that these key assurances are guaranteed for the future economic development to achieve the 2020 objectives mentioned above? In his address, the minister touched on a variety of issues which included energy security, fuel supply and pricing (especially gas pricing), renewable energy (RE) and conservation, nuclear option and the restructuring of the electricity supply industry. On the energy efficiency (EE), he also mentioned about the proposed National Energy Efficiency Master Plan that has set a 79.8 TWh target of total accumulated energy savings from three sectors identified; industrial, commercial and residential, for a span of 10 years from 2012. This will enable the reduction of 59.16 million tonnes of CO_2 from polluting the environment. In terms of energy security, the total energy saved is equivalent to the power generated from a 3.6 GW generation capacity based on current generation load. For RE, he indicated that the applications for a total of about 311 MW of various RE power plants have been approved under the RE Act with the grant of feed-in tariff (FiT) rates. The estimated RE capacity that may be developed by 2020 and 2030 could reach over 2000 MW and 3000 MW respectively [1].

Under the ETP formulated in 2010, one of its project code-named Entry Point Project 11 (EPP 11): Deploying Nuclear Energy for Power Generation which is led by the Performance Management and Delivery Unit (PEMANDU), projected the development of two units of nuclear power plants (NPP) of 1000 MW each, with the first unit to be commissioned in 2021 [2]. These two units are estimated to cost about RM 21.3 billion (US$ 7 billion). Interestingly, a KeTTHA's presentation in the 2012 National Energy Security Conference has included a slide as illustrated in Fig. 1 below that shows the electric power demand and supply projection for Peninsular Malaysia up to 2013 [1].

The slides give excellent presentation and clearly show the demand projection and generating plant development planned to achieve an appropriate reserve margin of below 20% from the current excessive margin of 40%. However, the table within Fig. 1 appears to give incorrect information as the current installed capacity in Peninsular Malaysia is already slightly over 22,000 MW even without any nuclear (shown as 5000 MW in the table). As indicated in the chart, the required generating capacity by 2030 will need to be around 30,000 MW, with nuclear likely to be in the picture. What is perhaps less comforting from the presentation is the absence of any reference to EE and potential RE development in the energy mix especially when the RE Act and its accompanying FiT mechanism has been implemented since Dec. 2011 [3,4].

2. Electricity supply and demand

Rising energy demand in the country, driven by its robust economic activities, only serves to exacerbate the challenges already faced by the energy sector. Industry experts reckon that unless Malaysia restructures its power sector, meeting the rising energy demand will be tough job as the country advances up the value chain. All the on-going economic activities need to be powered up by sufficient and stable energy supply, and the country cannot afford to keep its energy sector status quo. Reform activities are therefore essential to keep up with the changing times and economic demography so as to ensure that power sector's supply chain remains healthy enough to support the growth.

Let us revisit the statement made by the Minister of KeTTHA which assured the nation of this provision in stating that [1];

> *"Going forward, we will ensure that the energy supply in Malaysia is sufficient, reliable and cost effective to safeguard our regional competitiveness in trade and industry".*

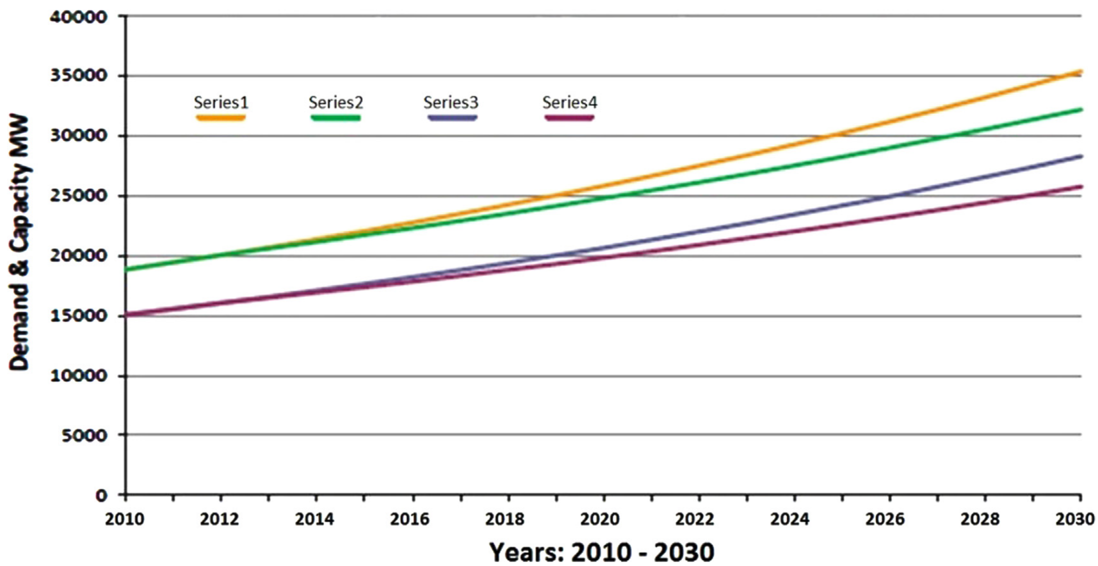

Fig. 2. Projected power demand (business-as-usual is at 3.2% pa growth rate).

Some of the pertinent points that need to be assured or convinced that the above commitment can be guaranteed for the nation up to the time horizon of 2030 are listed below:

- The projected power demand for the period in question.
- The existing and planned additional power generating plant to be developed during the period and their timing to suit the demand needs.
- The successful implementation of the RE Act and its related FiT mechanism.
- The impact of the forthcoming Energy Efficiency and Conservation (EE&C) Act scheduled to be enacted by 2014.
- How these issues will influence the economics of the planned system development for national energy security.

Now, the concern will be the expected demand forecast based on the currently known parameters. The expected demand growth rate under a business-as-usual (BAU) scenario is at 3.2% per annum (pa) for the period 2010–2020 as reported in Malaysia's state-owned power utility company, Tenaga Nasional Berhad's (TNB) annual report for the year 2009. The demand growth according to an EE scenario foresees a conservative reduction in the demand of 0.5% pa starting in 2013 so that the demand reduction by 2030 will be 9.0% under the BAU case [5]. The EE scenario is based on the assumption that the EE&C Act would be enacted by early 2014 but that its impact would begin to be seen from 2013 as awareness and promotion efforts have been on going.

Moreover, the larger electricity consumers who use more than an average of 500,000 kWh a month are obliged to practise formal energy management under the Efficient Management of Electrical Energy Regulations (EMEER), which came into force in Dec. 2008 [6]. Additionally, electricity tariffs are also expected to increase as gas subsidies are gradually reduced by the government. This action would likely "persuade" more electricity consumers to consider implementation of EE measures to reduce their costs of energy, thus accelerating the adoption of EE initiatives by all categories of consumers.

The demand saving from adoption of EE, whether voluntarily or when mandated under the EE&C Act is envisaged to be only 826 MW by 2020 and 2547 MW by 2030 [1]. These figures are far more conservative than the figures quoted by the Minister since the EE&C Act has yet to be enacted and its provisions be implemented and enforced. This shows that it may be possible

Table 1
Projected conventional power generation capacity (in MW) to 2030.

Year	2011	2015	2020	2025	2030
Data A	22,100	22,100	20,000	25,300	25,300
Data B	22,100	22,100	24,100	29,400	25,300

A – assuming the 1st generation IPPs retire before 2020. B – assuming the 1st generation IPPs extend 10 years and that EC's additional 5300 MW bids are implemented between 2020 and 2025.

Table 2
RE generation capacity projections (in MW) to 2030.

Year	2011	2015	2020	2025	2030
With PVPPs	154	1275	3140	4643	7068
Without PVPPs	134	980	2080	2888	3993
Conservative estimate[a]	70	500	1400	2400	3400

PVPP – Photovoltaic power plant.
[a] Authors' estimate without photovoltaic power plants (PVPPs).

to achieve a demand reduction equivalent to about 3.6 GW as has been mentioned by the Minister, but only by around 2030 and only if the efforts under the EE&C Act are pursued at a more aggressive pace than the conservative basis indicated above.

The chart in Fig. 2 demonstrates the projected power demand and generation capacity development required to ensure adequate (25%) reserve margin for safe and reliable power supply in Peninsular Malaysia. Now consider the known power generation capacity and its additions as announced by KeTTHA and the Energy Commission (EC). The current generation capacity is about 22,100 MW while licenses for two coal-fired power plants of 1000 MW each have been awarded to date (one each to TNB and Tanjung Bin power plant) for commissioning around 2015 and 2017 [7]. EC has also publicized its request for bids for a total of about 7300 MW of power generating capacity (include the 2000 MW already awarded) and scheduled for commissioning by 2020. It is also assumed that this capacity would not include the proposed NPP where the first unit is scheduled to be commissioned in 2021 (after 2020) [8].

These initiatives have been stated to be necessary to replace the decommissioning of some of the first generation independent power providers (IPPs) with an estimated capacity of 4100 MW

whose original licenses are due to expire by 2020. Latest reports indicate that the EC has negotiated successfully for the possible extension for few of the first generation IPP licenses for up to 10 years [9,10]. Under this scenario, the total power generating capacity for the duration up to 2030 could be of the order as shown in Table 1. These numbers exclude consideration of any existing plant that is scheduled to be decommissioned during the period up to 2025.

The RE capacity development under the RE Act and the FiT mechanism is expected to add substantial power generating capacity to the electricity supply network in Peninsular Malaysia during this period. However, it is estimated that the actual RE capacity development may not match the initial projections as the plantation waste (as feedstock) has now become a valuable commodity and has become too costly to burn for power generation due to its alternative uses [11]. Hence, a conservative and more realistic forecast is projected and considered here in Table 2 for comparison with the official forecast. The revised grid connected power generation capacity in Table 1 may thus be moderated as in Table 3.

KeTTHA has also formulated the National EE Master Plan (NEEMP) which had been peer-reviewed by the Asia Pacific Economic Cooperation (APEC) team of industry experts [12]. KeTTHA is currently in the process of formulating an EE&C Act to enable accelerating the adoption of EE in Malaysia and also implemented its Sustainability Achieved via Energy Efficiency (SAVE) program since July 2011 as part of ETP's EPP9 to catalyze the adoption of EE through the purchase and usage of EE appliances (such as the 5-star rated refrigerators and air conditioners) [13–15]. Figs. 3 and 4 are snapshots of the SAVE program from different local agencies.

Table 3
Projected total grid connected power generation capacity (in MW) to 2030 (after moderation).

Year	2011	2015	2020	2025	2030
Data A	22,100	22,600	21,400	27,700	28,700
Data B	22,100	22,600	25,500	27,700	28,700

A – assuming the 1st generation IPPs retire before 2020. B – assuming the 1st generation IPPs extend 10 years and that EC's additional 5300 MW bids are implemented between 2020 and 2025.

As mentioned earlier, government's plans for the NPP have been incorporated in the ETP under EPP11 with the first unit of 1000 MW scheduled for commissioning in 2021. However, the development of an NPP is now an even more controversial issue than it was initially, following the unfortunate Fukushima NPP meltdown in March 2011 [16–19]. Hence, the potential 2000 MW capacity from the proposed NPP units is not considered for this discussion. A comparison of the required and anticipated power generation capacities in Malaysia to satisfy the power demand needs under an EE scenario is shown in Table 4. This somehow suggests that Malaysia does not necessarily need to have any nuclear (or add other fossil-fuelled) power generation plant until after 2025 provided that the RE development (even after moderated) and adoption of EE initiatives (even on a conservative basis) are pursued diligently.

3. Possibilities, constraints and impact of EE&C initiatives

From the previous section, it is shown that Malaysia may not need to add any nuclear or other fossil-fuelled power generation plant until after 2025 provided that the RE development (even when moderated) and adoption of EE initiatives (even on a conservative basis) are pursued diligently. This is of course subject to the potential retirement of existing fossil-fuelled power plants (whether operated by IPPs or TNB) as it would naturally warrant an earlier planting up of new proposed power plants, which will be addressed in the later part of this write-up.

Obviously, these projections also depend on the actual pace of adoption of EE practices and the rate of development of RE power generation under the RE Act and its FiT mechanism. The development of RE in Malaysia is being handled by SEDA as mentioned before, under the provisions of the RE Act and its related FiT mechanism. There is no dedicated agency to implement EE&C initiatives although SEDA is expected to do so when the EE&C Act is enacted. Therefore, it is worth to look at the possibilities,

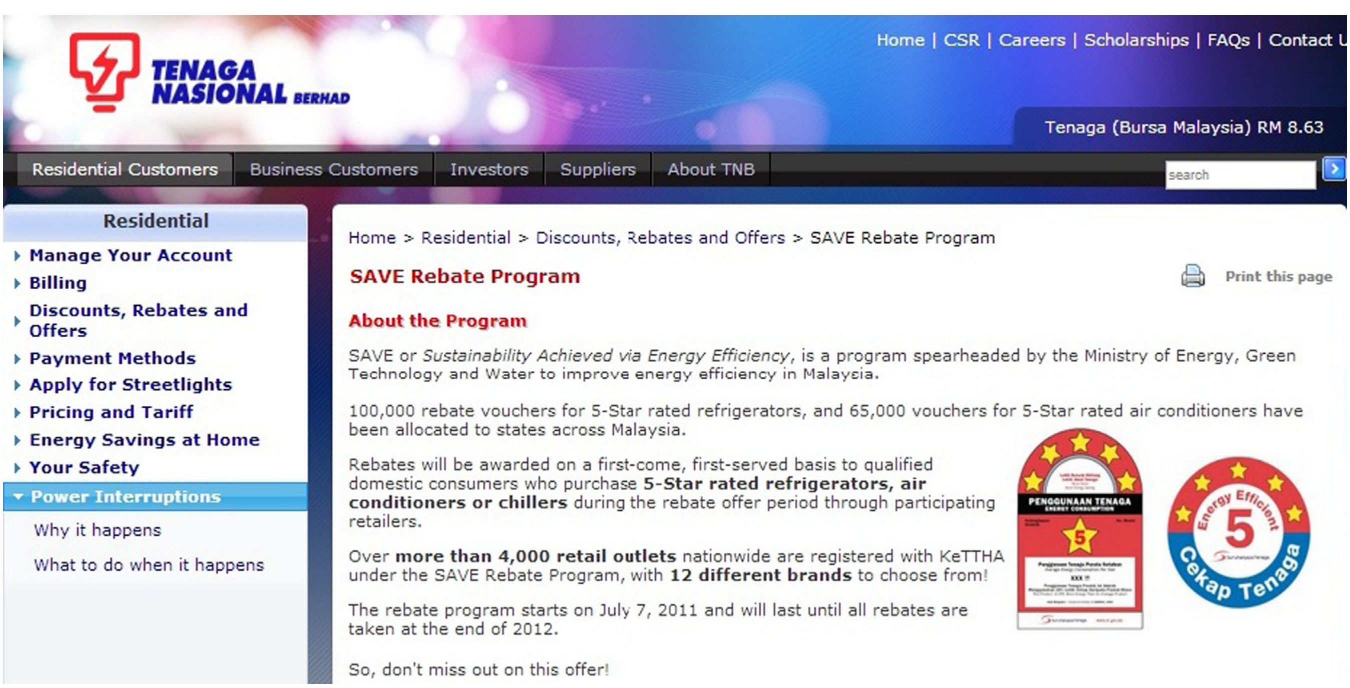

Fig. 3. Snapshot on the SAVE program in TNB website.

Fig. 4. Snapshot on the SAVE program in ETP website.

Table 4
Comparison of power supply and demand balance (in MW) to 2030 under an EE scenario.

Year	2011	2015	2020	2025	2030
Market demand	15,072	17,378	19,826	22,604	25,752
Gen. cap.	22,100	22,600	25,500	27,700	28,700
Gen. cap. needed (+25% from market demand)	18,840	21,723	24,783	28,225	32,190
Gen. cap. shortfall	nil	nil	nil	525	3490

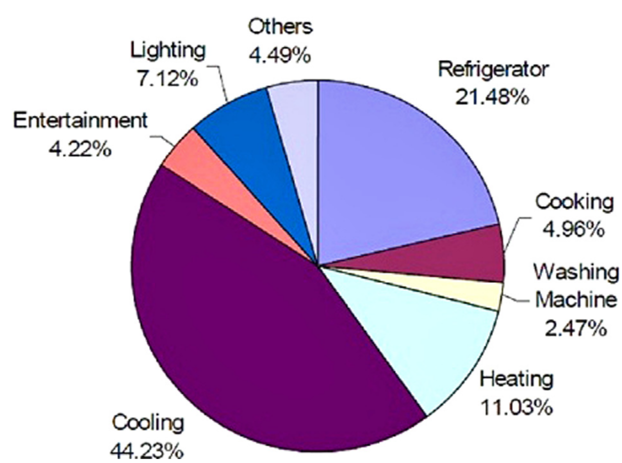

Fig. 5. Average electricity consumption breakdown.

constraints and impact of pursuing the desired EE&C initiatives and assess the likelihood of achieving the target savings.

First of all, there is widespread public skepticism (at least in Malaysia) as to whether the frequently touted EE initiatives can really deliver the promise made for it. How difficult, or easy, is it to achieve the ambitious demand saving targets that are often announced by various authorities and parties? Secondly, even if the skepticism can be overturned, there would still be some doubts as to how much impact can EE have on the national power demand. The chart in Fig. 2 earlier indicates a potential demand saving of about 826 MW by 2020, at a conservative demand saving rate of about 0.5% in demand per annum. A demand reduction of about 826 MW, together with a reserve margin of 25% equates to a generating capacity need of about 1030 MW which could require over RM3 billion (US$ 1 billion) in capital investment, a tidy sum to save indeed. But what does this mean to an ordinary consumer? The first response from a typical consumer would probably be "*So? Does it mean I have to pay more for my electricity?*", which is actually a fair response coming from a consumer whose first preference would be "*What is it in for me?*". From a consumer's perspective on this demand saving issue, a consumer would certainly be happy to contribute to the national EE objectives if by doing so, he or she can also save some electricity costs.

Since that refrigerator, air-conditioner (A/C) and lighting are considered the most common electrical appliances found in almost every household nowadays (see Fig. 5), there are several EE initiatives that can be exploited by all categories of consumers and a few simple and easy initiatives are considered. Part of the initiatives taken by the government to promote EE among consumers is also exemplified as shown in Fig. 6. Non-government organization (NGO), with the support from government and

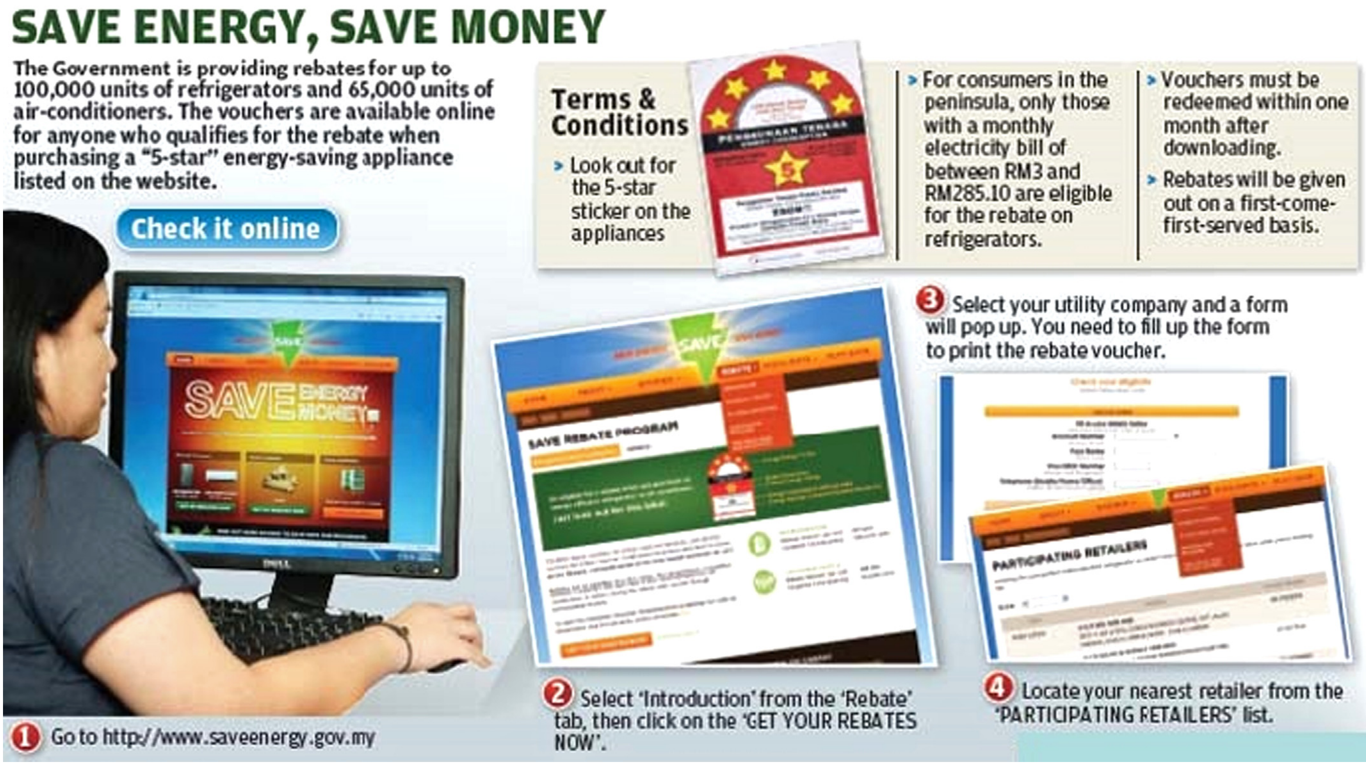

Fig. 6. Part of the various initiatives from the Malaysia government to promote EE and its usage.

industries for the benefit of the people and country, also plays their role in an effort touted as National Energy Efficiency Awareness Campaign, or better known as SWITCH!, whereby consumers should switch off the power when not in use and switch to EE products. Its website functions as a portal for all energy related matter which is layman-oriented, such as programs and public talks and tips on how to save energy [20].

3.1. Refrigerators (fridges)

The Energy-Efficient Refrigerator (EER) and Labeling Program is a program introduced in 2005 to promote energy-efficient refrigerators by introducing labels showing the energy use of domestic refrigerators and has since expanded to include fans, televisions, A/Cs and ballasts. It is open to all manufacturers on a voluntary basis. This program aims to create awareness on the existence of energy-efficient refrigerators in the market to general consumers and encourage manufacturers, importers, and dealers of refrigerators to promote energy efficient refrigerators. The ranking of refrigerators for all models tested by SIRIM is based on the Star Index, which will determine the star ranking of specific models for 1 and 2 door types of domestic refrigerators. The least energy efficient products are labeled with a "One Star" and the most efficient products with a "Five Star" rating. The "Star" rating for each model is shown by the comparative label that will be used for models approved by the EC. Household appliance will be labeled with an EC label that ranges from One-Star to Five-Star [21]. A sample energy label is illustrated in Fig. 7.

A 5-Star fridge is estimated to be about 25% more efficient than a standard 3-Star fridge. The chart in Fig. 8 illustrates the potential savings that consumers can gain from changing to EE type 5-Star fridges for a typical 400-litre fridge for which the price premium for a 5-Star fridge is less than RM200 (US$ 67) only. The chart also shows that even on the present subsidized tariff, consumer will recover the premium price for the 5-Star fridge in a few years and any savings beyond that will consider as "profits". If the fuel subsidies are reduced and the electricity tariffs increased, then the payback period for the price premium will be shorter and the "profits" would start earlier.

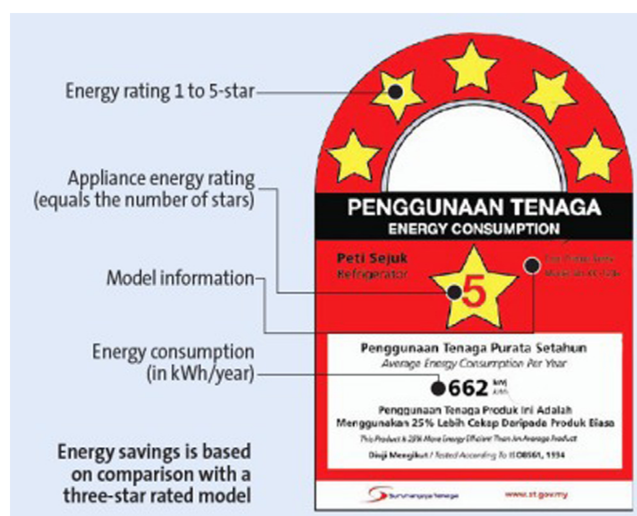

Fig. 7. Sample of Malaysia's Energy Commission energy label for refrigerator in Malaysia which uses numerical and star count format.

In conjunction with the launching of the SAVE program in 2011, KeTTHA even gave out 100,000 and 65,000 rebate vouchers on first-come-first-serve basis to qualified domestic consumers to purchase the 5-Star fridge and A/C, respectively [15].

3.2. Air-conditioner

Another attractive option would be the replacement of typical window or split type A/Cs with their 5-Star or inverter-type equivalent models. These EE A/Cs are capable to provide savings

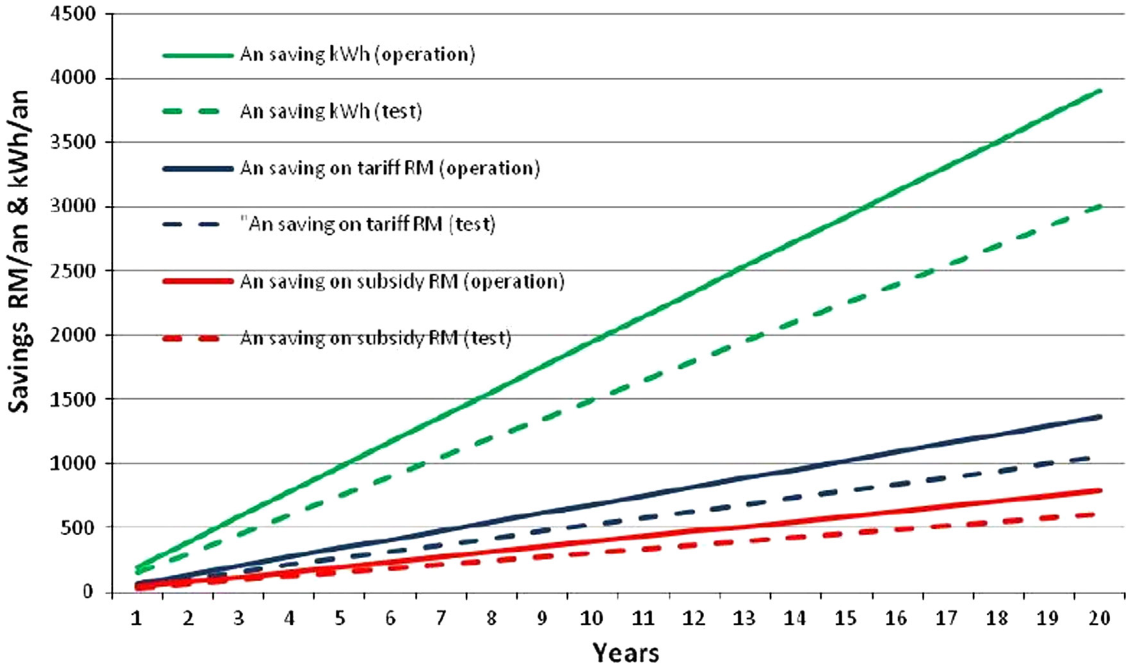

Fig. 8. Savings from 5-Star refrigerators.

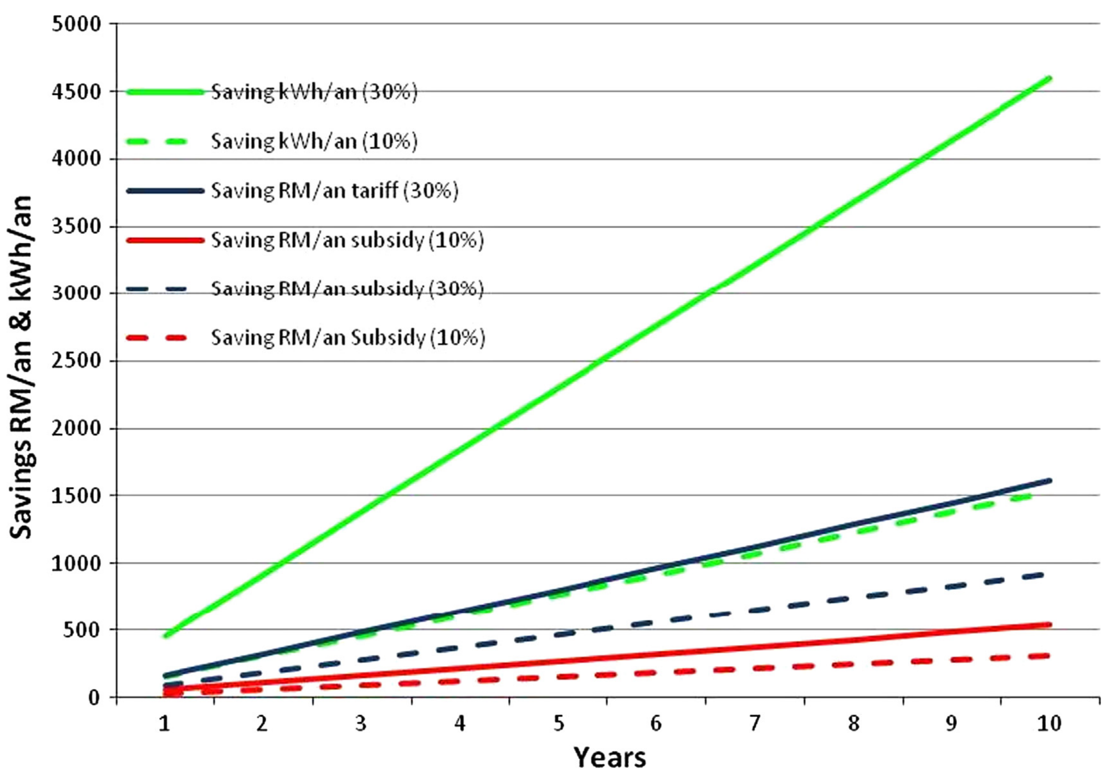

Fig. 9. Savings from EE split air-conditioner.

of between 10% and over 50% through lower current used during start-up, quicker to achieve desired temperature, quicker start-up time, no temperature fluctuations and no voltage peaks from compressor. These direct replacement initiatives by consumers will benefit them immediately through energy and cost savings as indicated in Fig. 9, which shows the savings for a typical 1-horsepower (HP) household A/C operated for an average of about 6 h a day. Obviously, the savings would be proportionally higher if the A/C usage is for longer periods.

3.3. *Lighting*

The replacement of incandescent lamps with the compact fluorescent lamps (CFLs) is a frequently used and straight-forward option in Malaysia. In fact, KeTTHA has mandated the phasing out of incandescent lamps by 2014. Many users have already caught on to the cost savings these CFLs provide and their use is rapidly displacing the traditional incandescent lamps. As a corollary, tubular fluorescent lamps, which are commonly used

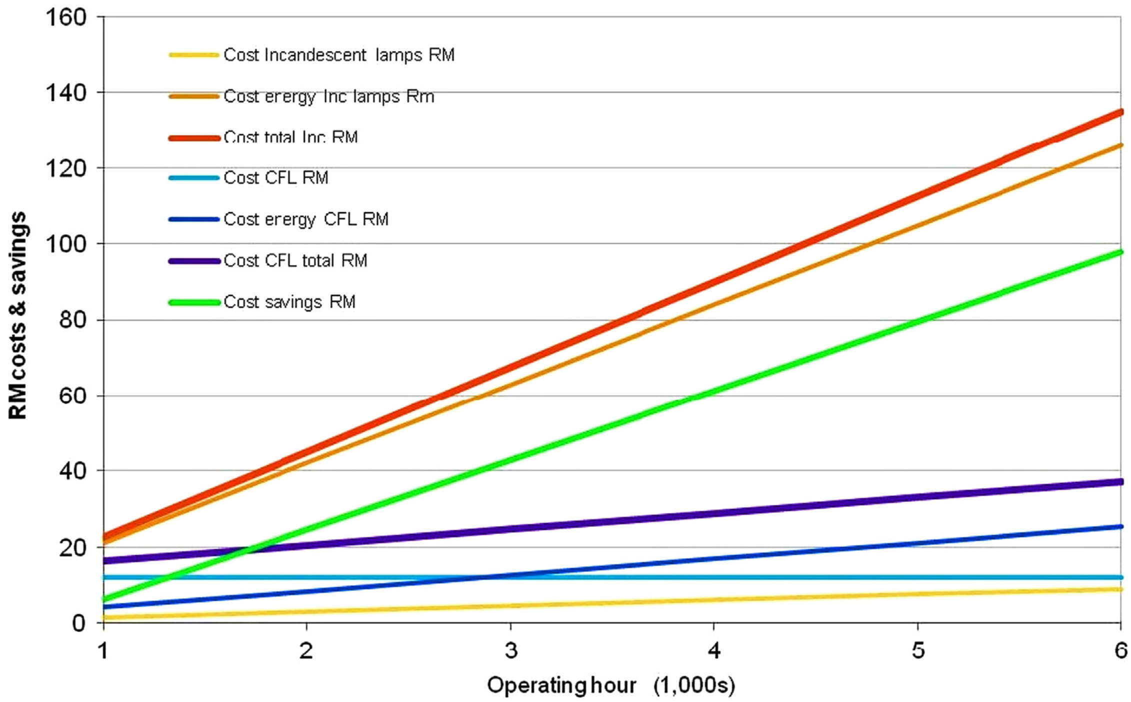

Fig. 10. Cost comparisons for different lightings.

for commercial and residential purpose, also have more energy efficient alternatives. The traditional T12 and T8 type of tubes can be replaced by the more efficient T5 tubes which give the same lighting level with about one-third reduction in energy consumption (e.g. a 36 W T8 tube can be replaced by a T5 tube of about 24 or 28 W). T5 fluorescent lamps have a higher luminous efficacy than T8 or T12 lamps. Luminous efficacy indicates how much light a lamp generates from the energy it consumes. The higher the value, the more energy efficient the lamp is. The luminous efficacy of T5 lamps is about 100 lm/W, while those of T8 and T12 lamps are only about 80 lm/W and 70 lm/W respectively. Furthermore, T5 lamps are also 40% and 60% smaller in diameter compared to T8 and T12 lamps [22]. The chart in Fig. 10 shows the cost savings from the use of CFLs replacing incandescent lamps. It illustrates clearly the higher cost of CFL is recovered from the energy savings within the first 1000 h of use.

The few examples above have illustrated that electricity consumers can derive cost savings for themselves by adopting simple EE initiatives for their own benefits and contribute in helping to achieve the national energy savings as well as carbon reductions in the process. But can they contribute to the demand reduction mentioned earlier? A fridge has a power demand of over 100 W, but its energy saving equates to only between 25 and 33 W. It is estimated that there are about 9 million fridges of these types in operation in Malaysia (7 million for domestic consumers and 2 million for commercial and industrial users, excluding the large heavy duty commercial and industrial units). Thus a change of all refrigerators can contribute to a demand saving of between 225 and 297 MW.

Similarly, a 1-HP A/C has a power demand of the order of 0.9 kW but the equivalent saving demand reduction would be of the order of 25–70 W (inverter type). By assuming that the total number of such A/C units in operation is same as the refrigerators; 9 million units comprising say 25% of residences with an average of 3 A/Cs each and very conservative estimation about 700,000 commercial consumers with an average of about 5 units each, hence the demand reduction from replacing them to energy efficient A/Cs can be of the order of 225 to over 600 MW.

Where A/Cs are used for cooling, the inclusion of roof insulation can further help to reduce the cooling power demand as many premises in Malaysia, whether residential, commercial or industrial, are not equipped with adequate roof or wall and window insulation. Anecdotal evidence indicates that the rains in Kuala Lumpur city reduces power demand by about 3% in Peninsular Malaysia, which is equal to a demand reduction of about 450 MW on a maximum power demand of about 15,000 MW. Again, only a part (say 50% or 225 MW) of this reduction may be achieved with enhanced roof, wall and window insulation.

These three simple initiatives indicate a potential demand reduction of the order of between 675 and 1100 MW. No account is taken for any demand reductions from conversion to EE lighting loads for domestic premises as these reductions occur during the evening, or off-peak periods, even though the consumers will themselves save energy and costs. These simple options have not even touched on the far more substantial savings that may be derived from the large commercial and industrial facilities where the lighting, A/C and industrial process loads provide the opportunity for much more significant demand reductions.

Up to this stage, it seems rather vivid that the demand reduction projection of about 826 MW by 2020 is relatively not difficult to achieve. The next step that should follow is to have relevant government agency to conduct sustained promotion efforts to convince consumers to adopt these energy saving initiatives. The monetary savings shown in the earlier figures should be sufficient incentive for consumers to take up the initiatives without much persuasion and in the process help reduce the need for more coal-fired or any NPPs to be developed in Malaysia.

There is yet any legislation to mandate the adoption of EE&C initiatives nor is there any dedicated agency to implement EE&C initiatives, although it is understood that KeTTHA is actively pursuing them. Previously on the demand reduction potential of 826 MW by 2020 (which with a reserve margin of 25% equates to a reduction in the need of generating capacity of about 1030 MW) could thus save over RM 3 billion (US$ 1 billion) in capital investment.

3.4. Industries and commercial

Larger potential of energy and demand savings actually lies in the industrial and commercial consumers who essentially use almost 80% of the electricity in Peninsular Malaysia, 70% in Sabah and over 75% in Sarawak. Most commercial and some industrial users have significant A/C cooling loads, using window or split units as well as large centralized chillers and extensive lighting loads. Experience from some energy audits for commercial consumers show that A/C energy use share being between 50% and 60% and lighting energy use share being up to 30% [23]. The share of A/C and lighting energy consumption is not as well-known but on a conservative basis, may be of the order of about 10% of their total consumption of each component [24]. It is also reported that buildings actually consume nearly 40% of the energy demand in most countries and 40% out of that comes from chillers [25,26].

Centralized chiller-type A/C plants normally operate for 20 years or more. Hence, their operating efficiency may be compromised if they have not been adequately maintained. Moreover, technology advancement over the years makes new centralized chillers far more efficient nowadays. That chiller efficiencies improvement may warrant their replacement on purely economic grounds in view of the current electricity tariffs and their anticipated increase in line with government's declaration to remove fuel subsidies gradually. This is more so since such consumers can avail tax benefits that the government has provided for the adoption of EE initiatives by companies, such as the Investment Tax Allowance (ITA) [27]. Also, by replacing every centralized chiller plant with a newer more efficient plant can also provide energy cost savings of the order of RM 300 (US$ 100) per annum (based on average operation for about 10 h per day) for typical users such as offices, shopping malls, hospital and the like. So, how much additional electricity demand savings are possible if these consumers change their older chillers? The latest EC statistics available showed that industrial and commercial total use stand at 47,218 GWh and 36,821 GWh respectively in 2011 [28].

When it comes to EE in the commercial and industries sector, building design has become more crucial in order to achieve any desire savings, as mentioned earlier 40% of energy demand in most countries actually comes from buildings. So serious is the government in this buildings sector that in 2010, an international collaboration project was launched between the United Nations Development Program (UNDP) and the Public Works Department of Malaysia (PWD), known as the Building Sector Energy Efficiency Project (BSEEP) that runs for 4 years (2011–2015). The project objective is the improvement of the energy utilization efficiency in Malaysian buildings, particularly those in the commercial and government sectors, by promoting the energy conserving design of new buildings and by improving the energy utilization efficiency in the operation of existing buildings. The extracts from the BSEEP show that the Building Energy Intensity (BEI) for EE buildings in Malaysia as well as the ways in which energy savings can be achieved. These demonstrated the tremendous energy saving potential through design of EE buildings and the EE features that can be employed [29–33]. One of the earlier significant EE buildings is the low energy office (LEO) that was completed in 2004 and currently houses KeTTHA [34]. It has actually set the benchmark for more EE buildings that follow, such as the officially first Green Building Index (GBI) certified building, the Green Energy Office (GEO) that houses the Malaysia Energy Centre since 2009. A more recent building that has actually achieved a platinum-grade (the highest in GBI rating) in 2011 is the EC building (see Fig. 11). Since then, dozens of GBI-rated buildings, both residential and commercial, have been erected throughout the country, setting a new standard in the local building sector [35,36].

Thus, a very conservative energy saving estimate of only 10% for the cooling load equates to about 1494 GWh savings for commercial users and 400 GWh savings for industrial users, making a total saving of about 1894 GWh. This energy saving would imply a demand saving of about 309 MW, which would imply avoiding the need for power generation capacity of about 380 MW. In fact, actual savings from replacing old chillers with state-of-the-art EE chillers can be as much as 25% without sacrificing any cooling capability.

Fig. 11. GBI's platinum-rated EC building.

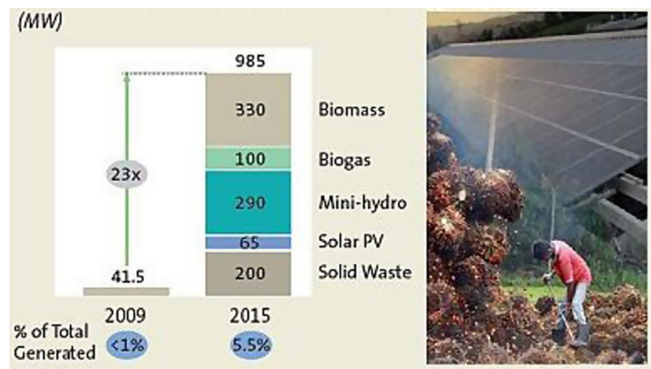

Fig. 12. Malaysia's planned increase in RE capacity [37].

Similarly, EE lighting for commercial and industrial consumers would provide additional savings. Using conservative shares of energy used (20% for commercial and 10% for industrial users) and conservative prospective savings to be achieved (only 20% compared with known savings of about 30% for T5 fluorescent tubes against the current standard T8 tubes, and up to 50% with LEDs, but at a much higher cost), the savings from changing existing lighting to be more efficient alternatives can be about 1996 GWh per annum. This energy saving would equate to a demand saving of about 326 MW, which would imply a reduction in power generation capacity required of about 407 MW.

The total potential energy savings from using EE lighting and replacing existing older centralized chillers with more efficient units can be as much as 3890 GWh which would equate to a demand reduction of 635 MW. Allowing for a 25% reserve margin, this would equate to a reduction in required power generating capacity of 787 MW.

4. Yield projection from RE

In 2002, Malaysia introduced a new fuel mixed strategy; by adding RE as the 5th fuel into its existing Four-fuel Diversification

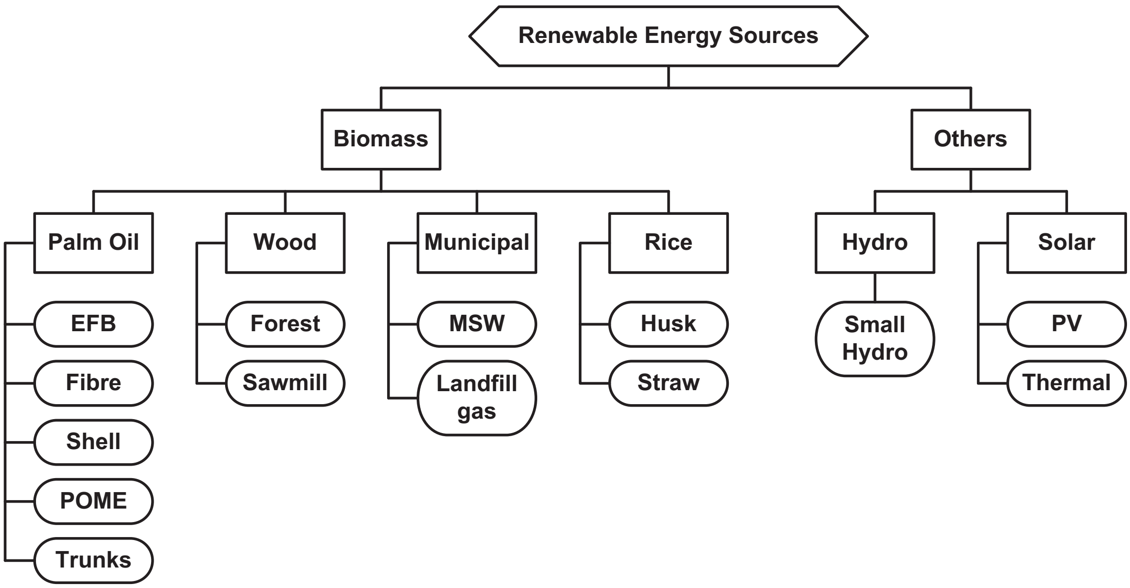

Fig. 13. Malaysia RE sources [62].

Strategy to become five. The Ministry of Energy, Water and Communications was also re-established in 2009 to become the current KeTTHA as part of government's initiatives to promote RE as an alternative energy source. Malaysia plans to achieve 985 MW or 5.5% share of RE in the energy mix by 2015 (see Fig. 12) in which at present it contributes less than 1% to the energy mix. By 2020, the target is for RE to comprise 11% or 2080 MW of overall electricity generation in the country [37].

KeTTHA has taken advantage that United Nations Development Program / Global Environment Facility (UNDP/GEF) supported the Malaysia Building Integrated Photovoltaic (MBIPV) project (2006–2011) to pursue the formation of a RE Policy and Action Plan (REPAP) and enactment of the RE Act 2011, which was passed in April 2011 [38–41]. This included the FiT mechanism as well as the Sustainable Energy Development Authority (SEDA) Act 2011 to establish a dedicated agency to implement the RE Act and its FiT mechanism. Implementation of the RE Act to accelerate the development of the RE power generation in Malaysia commenced on 1 Dec. 2011 and appears to be on track to achieve its targets so far.

Besides the MBIPV project, another notable project that worth highlighting here is the Small Renewable Energy Power (SREP) Program that ran from 2001 to 2010, started with the target of 500 MW of small scale RE technology by 2005 but only 12 MW was achieved. The target was then lowered to 350 MW and in the end only 62 MW was realized [42]. Although the SREP did not meet its targets and was seen as a failure due to its many flaws in the program itself, it offers many lessons for energy planners and policymakers in Malaysia [43].

Also, the high-profile Bakun hydroelectric dam in east Malaysia, which was initially built with the objective to overcome the projected power shortage in the Peninsular but ended up with the scrapping of its high-voltage transmission submarine cable due to high cost being cited as the main reason [44,45]. Subsequently, the Sarawak state government (where the dam is located) reiterates that it will absorb all the 2400 MW capacity of the dam for its massive Sarawak Corridor of Renewable Energy (SCORE) project [46–48].

Generally, the RE sources in Malaysia can be summarized as in Fig. 13 below and there shall be no further elaboration here as they have been well documented over the years. More information on Malaysia's RE scene is available in [49–61].

Table 5
SEDA presentation “RE Act & Subsidiary Legislation” on April 21, 2011 [64].

RE installations	Biogas	Biomass	Small hydro	Solar PV
RE installed capacity (MW)	4	10	10	0.006
RE generation/mth (MWh)	2044	5100	4167	0.6
FiT rate/kWh (RM)	0.34	0.33	0.24	1.46
FiT duration (years)	16	16	21	21

The demand saving projections in the previous section would be subject to the potential decommissioning of existing fossil-fuelled power plants and this retirement could naturally warrant an earlier planting up of new proposed power plants. However, this topic needs to be considered from a wider perspective in which it will be addressed later in this write-up. These projections, besides depend on the actual pace of adoption of EE practices, the rate of development of RE power generation under the RE Act and FiT mechanism is obviously equally important. The development of photovoltaic (PV) farms, or also known as PV power plants (PVPPs) later generated some negative repercussions as they have somehow failed to take off in a large scale to generate significant capacity even though its potential is practically limitless [51]. This fiasco and the uncertainty of biomass feedstock supply for RE plants [63] may create some hiccups as to the rate of the overall RE capacity growth, not just for PV, during the rest of this decade. Therefore, the actual RE capacity may not match what has been planned under the RE Act.

This issue therefore warrants some caution regarding energy generation from PV power generating systems. In fact, there appear to be some serious misconceptions (and even apparently deliberate misrepresentation) on the role that PVPP can play for nation's future power needs and energy security. This is elaborated with the fact that conventional power generation meets customer demand that requires generation of about 6000 kWh per annum for every kW of consumer demand. RE from biomass, biogas, mini-hydro and solid waste to energy plants can generate roughly this amount of energy per unit of power capacity involved as shown in Table 5. The yield from PV is sadly so much lower, being only about 25% of that from the other RE sources as shown in KeTTHA's own presentation on the RE Act and Subsidiary Legislation [64]. Data in Table 5 equates to energy yield in Table 6 below.

This shows that PV generated electricity can only contribute about 25% of the energy that can be generated by other RE technologies and as required by the consumers. Thus, additional fossil-fuelled power plants will be required to satisfy the total consumers' demand. Even with, say, 15,000 MW of PV system capacity against the 15,000 MW of power demand, the fossil-fuelled (or other) power plants will still be required to meet the energy and net power demand shortfall (of the order of 70%), which could amount to about 10,500 MW as indicated in the hypothetical demand profile chart in Fig. 14 below.

5. Demand reduction analysis

Thus, the total demand reduction from the various initiatives from residential, industrial and commercial as mentioned earlier is tabulated and indicated in Table 7. The total savings from these initiatives will experience some diversity between their demands, thus the actual demand reduction will be less than the arithmetic sum shown. The impact of diversity may moderate the demand reduction to between 70% and 80% of the arithmetic sum. A conservative assessment at 70% makes the potential saving between 917 and 1230 MW. Allowing for the nominal 25% reserve margin for the generating capacity would mean that the generating capacity required to meet such a load could be reduced by between 1146 and 1538 MW.

These considerations show that the projected demand savings from EE (about 826 MW by 2020) are not exaggerated and can be realistically achieved, and in fact exceeded if pursued diligently. These savings should therefore be duly incorporated in any long-term

Table 6
Equivalent energy yield from Table 5.

Unit	Biogas	Biomass	Small hydro	Small PV	Large PV
kW	4000	10,000	10,000	6	–
kWh/mth	2,044,000	5,100,000	4,167,000	600	–
kWh/kW/mth	511	511	417	100	–
kWh/kW/year	6132	6132	5000	1200	1400

Table 7
Total energy demand reductions with all sectors combined.

Initiatives	Savings (GWh)	Market demand reduction (MW)	
		Min.	Max.
EE refrigerators	1380–1821	225	297
EE air-conditioners	1380–3678	225	600
Rain (insulation)	1380	225	450
EE chiller replacement	1894	309	380
EE lighting	1996	326	407
Total	8030–16,769	1310	2134

Fig. 15. Potential locations of nuclear power plants in Malaysia.

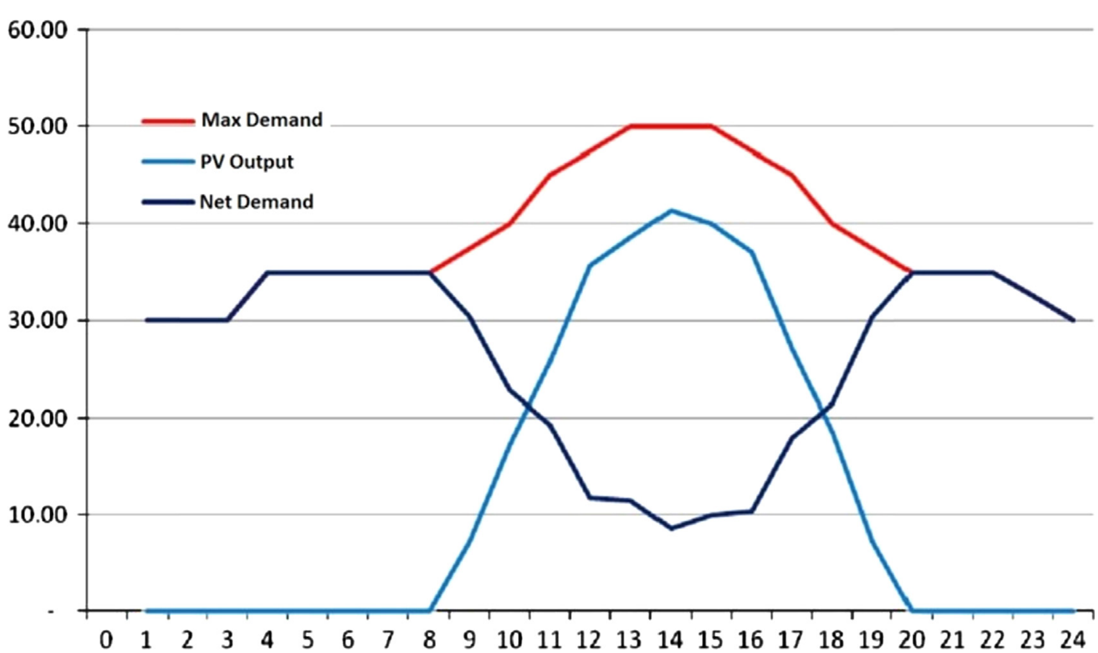

Fig. 14. Demand profile with PV generation.

Fig. 16. One of the many protests on the NPP proposal in Malaysia.

generation capacity planning exercise to ensure economically optimized system development to meet future national electrical energy needs.

However, there is no evidence to indicate that such considerations, as well as projected RE generating capacity development, have been taken into account in the system development as presented by KeTTHA during the 2012 National Energy Security Conference. Fig. 1 has shown the demand projection and generating plant development planned to achieve an appropriate reserve margin of below 20% from the current excessive margin of the order of 40%. Unfortunately, it fails to show any contributions from EE (3600 MW less generating capacity required as mentioned by the Minister himself) or RE generating capacity (projected to be between 2080 and 3200 MW) as have been announced repeatedly in the past [49,50,58,65,66]. Even more critically, KeTTHA presentation includes the development of the 5000 MW NPP by 2030 with even a few proposed locations being circulated around (see Fig. 15), despite the Fukushima disaster in 2011 and when the public has apparently shown severe resistance to such development in Malaysia thus far [67–69]. Many protests and peaceful rallies like the one as depicted in Fig. 16 have been organized since its announcement in 2010. Does Malaysia need the 5000 MW of NPP as projected by KeTTHA, or even the 2000 MW as planned by PEMANDU, with the first 1000 MW unit to be commissioned by 2021? But as for now, maybe a lot of people are relieved with the recent announcement by the Malaysia Nuclear Power Corporation on the delay of the first NPP, with a possible date later than 2021, citing reason that the feasibility study has been pushed back until late 2014 [70,71].

Referring to Table 4 earlier, NPP would not be needed until at least 2025. Nevertheless, even this likelihood is contentious in the light of the potential impact of EE and RE on the generation capacity needs. Licenses for a total of about 4100 MW from IPPs' generating capacity which comprise of combined-cycle (CC) and open-cycle (OC) gas-fired plants are due to expire between 2015 and 2020. However, the EC has successfully negotiated for the extension up to 10 years of these licenses for several first generation IPPs as mentioned earlier and these power plants in question are capable of operating satisfactorily during the proposed extension period. Besides this extension, these power plants can be judicially repowered with new power generating units at the current sites where the gas supply may still be available beyond the present license periods.

The CC plants that are to be retired have an average operating efficiency of about 40–45%, while the units being manufactured now claim design efficiency of the order of 60% and by 2020, can reach as high as 64%. The new plant may therefore be able to operate at an average efficiency of about 50–55%, which is about 20% higher than the current plant. This means the new CC power plants can generate up to 20% higher output than the plants they are replacing from using the same amount of gas supply. In addition, the exiting OC gas turbine plants could be converted to CC mode, which would increase their output by about 50% compared with OC operating mode [72,73].

Furthermore, there appears to be no serious restriction on the quantity of gas that can become available in the future, even if it is obtained through the import of liquefied natural gas (LNG) which would need to be re-gasified. In fact, the first such facility which is owned and operated by PETRONAS, an oil and gas company wholly-owned by the government, is already operational by end of 2012. Thus, the judicious repowering at the sites of the IPP plants that are to have their licenses extended before being decommissioned can provide about 800 MW to over 1000 MW additional generating capacity through a potential repowering exercise. This additional capacity could be realized between 2020 and 2025, to make up the potential generating capacity shortfall indicated due for 2025. Moreover, even the long-term LNG exports from Malaysia to other East Asian countries that were contracted in the last century are expected to expire before 2020. The capacity that has been exported so far can thus be made available for local use to power up the CC power plants, which are considered relatively cleaner than developing NPPs.

6. Conclusion

Obviously the prospects for enhanced adoption of EE, especially for the period beyond 2020 can help realize greater demand reduction and consequent need for additional power generating capacity, whether from gas, coal or especially nuclear. It must be remembered that a 1000 MW NPP is expected to require an investment of about RM 10 billion (US$ 3.3 billion), while a corresponding generation capacity reduction through EE can be achieved at much lower cost, probably below 20% of that. This alternative would also obviate the need for operating expenses to run the NPP over its lifetime, besides hindering negative public sentiments of any potential hazards, whether perceived or otherwise.

Additionally, the impact of EE and distributed generation from RE can also reduce the need for electricity supply transmission and distribution system reinforcement, thus reducing further capital investment in service operation by the utility such as TNB. The lower the capital investment in the supply system infrastructure, the lower will be the need for higher profits for the energy supply utility. This will automatically translate to a lower need for tariff escalation in the future that will burden the consumers due to higher energy costs. Successful promotion of EE and its adoption by consumers can even mitigate government's gradual removal of subsidies for gas supply for power generation, to a certain extent.

It is rather evident that Malaysia can safely defer the development of NPP to a commissioning date beyond 2025 or probably never, with the hope that more benign, green and clean forms of power generation can become available and viable for Malaysia in the future. Under this scenario, it is worth mentioning the following response from a very credible and world-renowned energy expert, Dr. Rajendra Pachauri of the International Panel on Climate Change (IPCC), who visited Malaysia in April 2011 to give a public lecture and share his perspectives on nuclear power and climate change, post Fukushima, when asked about Malaysia government's apparent decision to proceed with the development of the twin-unit NPP for commissioning by 2021, had made an interesting comment. He commented that Malaysia should harvest the lowest hanging fruits first, which in this case can begin by adopting EE, developing RE energy generation next, and then only go for more fossil-fuelled or nuclear-powered generation plants. His statement makes a whole lot of sense indeed. Undeniably, for Malaysia to stay on the right path to achieving the supply and demand balance in an optimally cost-effective manner, the energy sector will continue to be an interesting spectrum to watch.

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